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SOARD RADAR - AN/APQ-93

Review of Program since July 19, 1962

November 30, 1962

By

Westinghouse Electric Corporation

Air Arm Division

Baltimore 3, Maryland

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PROGRAM FOR SOARD AN/APQ-93

1. CONTINUED DEVELOPMENT
   - A. RESONANT RING IMPROVEMENT
   - B. ANTENNA IMPROVEMENT
   - C. RECORDER SPOT SIZE REDUCTION STUDY
2. RADAR MODIFICATION
   - A. TRANSMITTER, CROSSED-FIELD AMPLIFIER
   - B. IMPROVED MOTION COMPENSATION SYSTEM
   - C. RECORDER
     - LENS OPTICS REPLACING FIBER OPTICS
     - AUTOMATIC FILM SPEED CONTROL
3. DESIGN EVALUATION
4. ENVIRONMENTAL TEST
5. FLIGHT TEST
6. ACCESSORIES
7. INSTALLATION

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RESONANT RING IMPROVEMENT

		GOAL	MEASURED
1. ORIGINAL UNIT		0.5-1.0 MEG W.	0.23 MEG W.
		10 NANOSEC.	10 NANOSEC.
		20-40 W. AVGE.	9.2 W. AVGE.
2. LIMITING FACTORS	DRIVING POWER		
	LOSSES IN RING		
3. IMPROVEMENTS	RING LENGTH INCREASED		0.14 MEG W.
			20 NANOSEC.
	TUNING SHORTS IMPROVED		12.3 W. AVGE.
4 FURTHER IMPROVEMENTS	INCREASE RING LENGTH (FOLD)	0.40 MEG W.	
		30 NANOSEC.	
	INCREASE DRIVE POWER	48 W. AVGE.	

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ANTENNA IMPROVEMENT

I. SIGNIFICANT FACTORS - HIGH TEMP. DESIGN 550°F
- GAIN

A SPECIAL TECHNIQUES FOR HIGH TEMP. - STAINLESS STEEL BEAM
- ELECTRO-DEPOSITED NICKEL ELEMENTS
- FIBRE GLASS-RESIN PRESSURE COVERS
- HIGH TEMP CEMENT

B. RESULTING UNIT HAD EXCESSIVE LOSSES

MAX. THEO. GAIN	38.9db
CALCUL. LOSSES	-7.4
PREDICTED GAIN	31.5db
MEASURED GAIN	29.5db

C IMPROVEMENTS

MANIFOLD PHASE CORRECTION	.5db	
HIGH PRESSURE ADHESION	1.5db	
		2.0
PREDICTED IMPROVED GAIN		31.5db

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CFA TRANSMITTER SUMMARY

1. SIGNIFICANT FACTORS

a. POWER OUTPUT.....1-2 MEGAWATT

b. STABILITY.....PULSE TO PULSE PHASE STABILITY $< 5°$

c. PULSE WIDTH.....30 NANOSEC.

2. SPECIAL TECHNIQUES

a. CROSS-FIELD AMPLIFIER DEVELOPMENT

b. MATCH CHARACTERISTICS OF POWER SUPPLIES, MODULATORS, AND RF AMPLIFIERS

c. DARLINGTON LINE MODULATOR FOR CFA AND GRID PULSED TWT FOR INTERMEDIATE AMPLIFIER

d. MINIMUM WEIGHT DESIGN BY USING SF_6 INSTEAD OF AIR FOR HIGHER DIELECTRIC STRENGTH AND IMPROVED COMPONENT COOLING EFFICIENCY

3. PROGRAM

a. BUILT AND TESTED LABORATORY BREADBOARD MODULATOR

b. SFD FOR CFA TUBE DEVELOPMENT (1ST TUBE DEL. 12-17-62)

c. FLYABLE BREADBOARD 1-15-63

d. 2 PROTOTYPES DELIVERED 6-1-63 AND 7-1-63 (TO BE DESIGN IMPROVEMENTS OF FLYABLE BREADBOARD)

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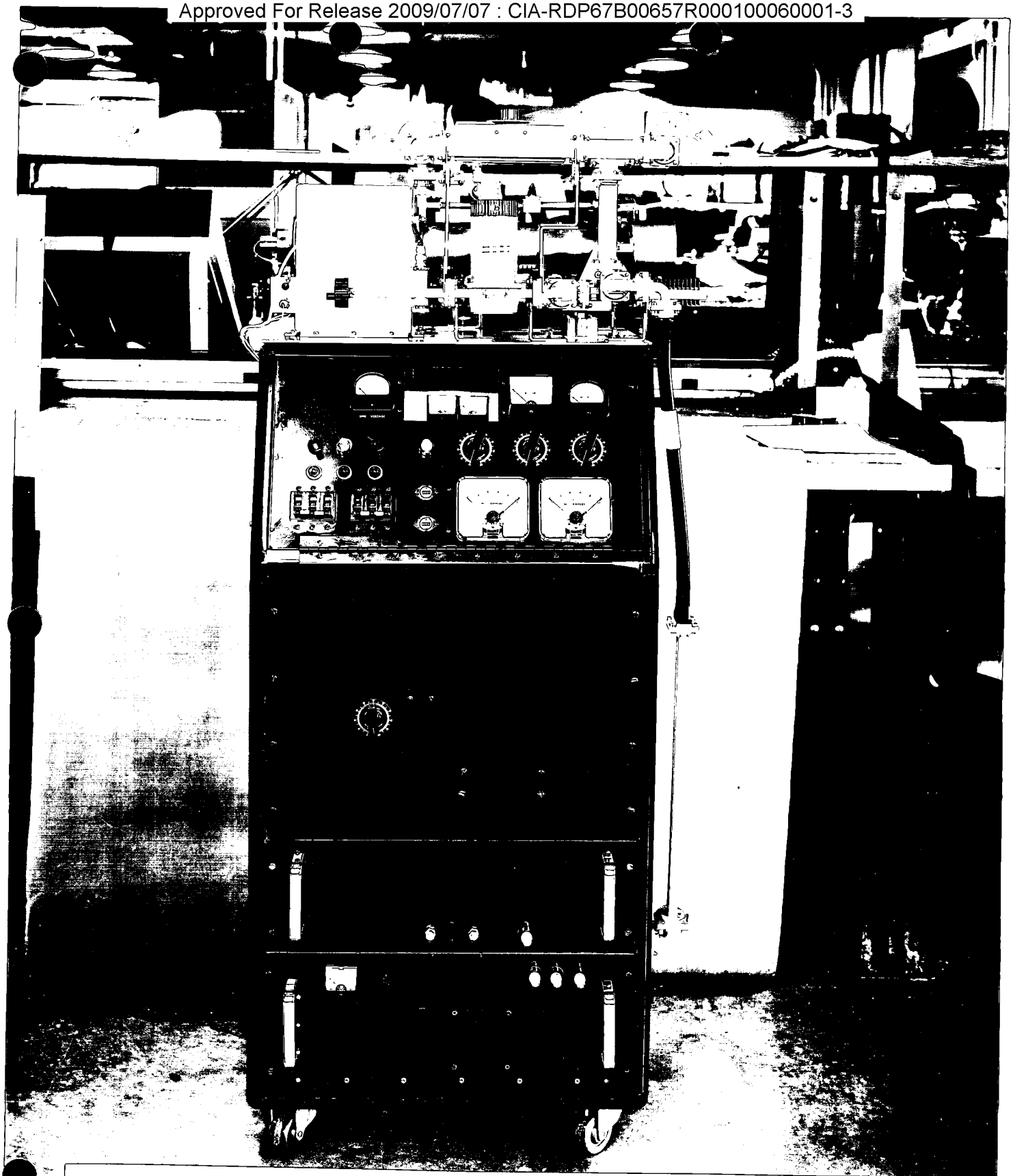
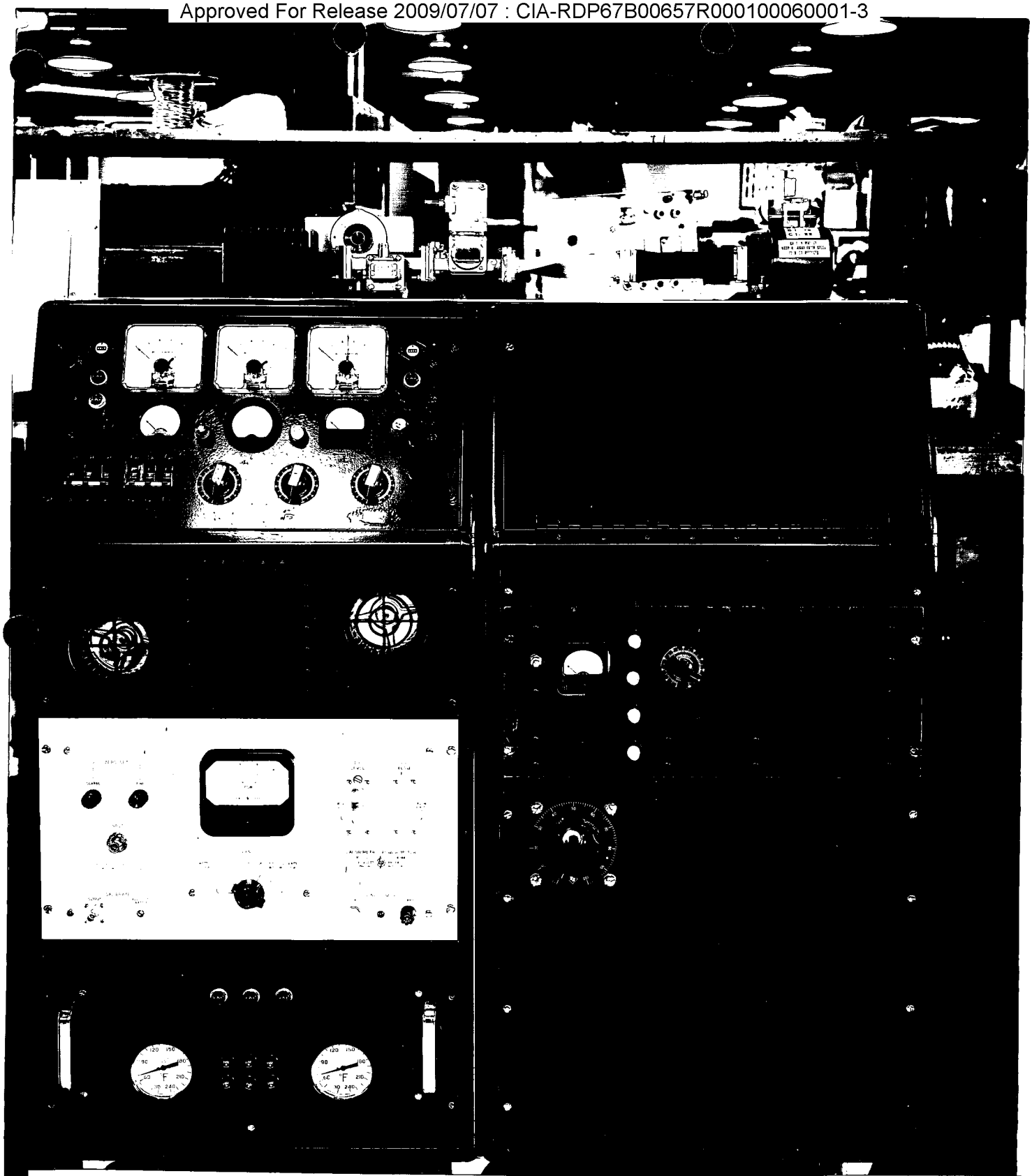
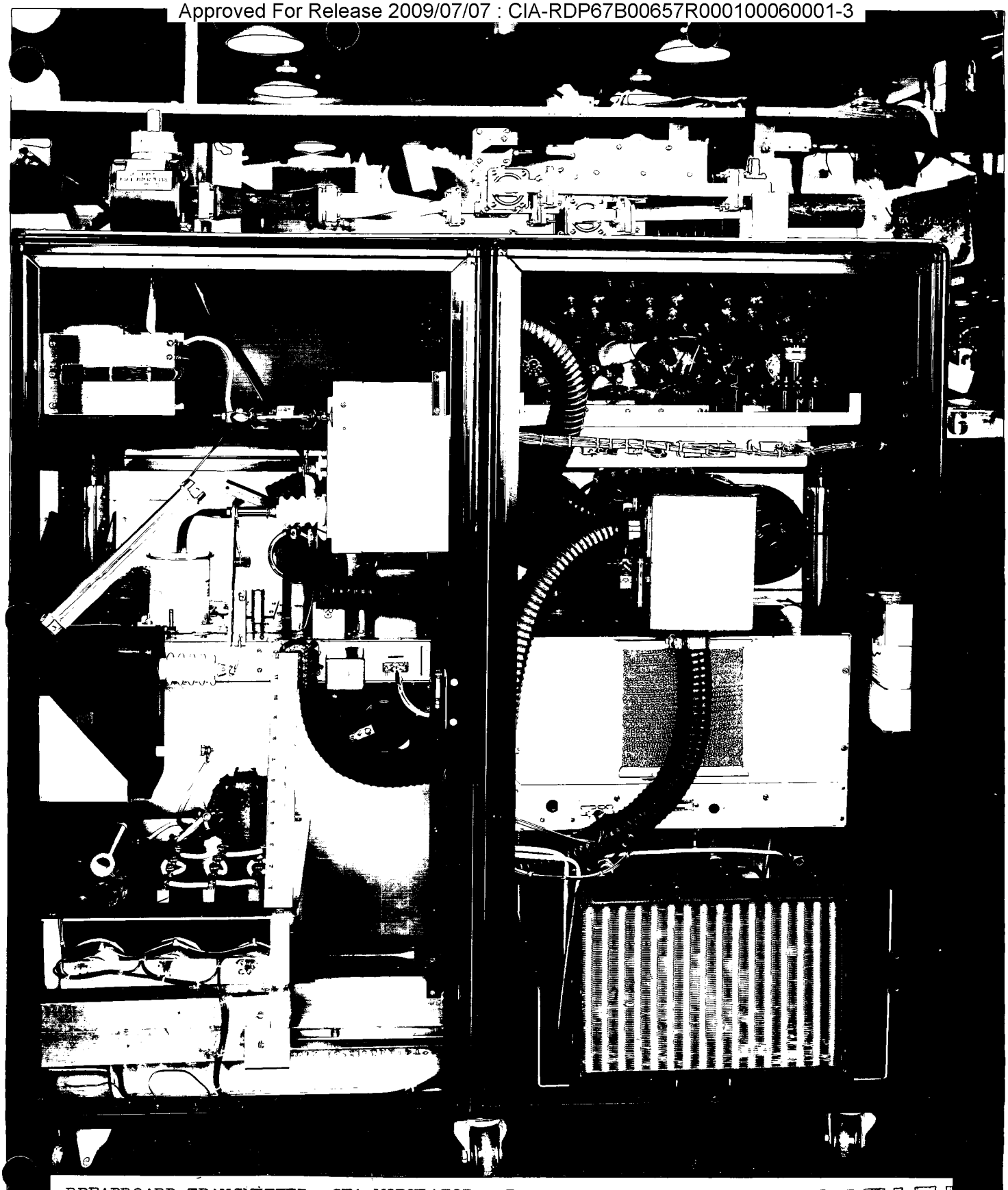


BREADBOARD TRANSMITTER, INTERMEDIATE AMPLIFIER - TWT, Modulator, Power Supply, Controls and Stalo.

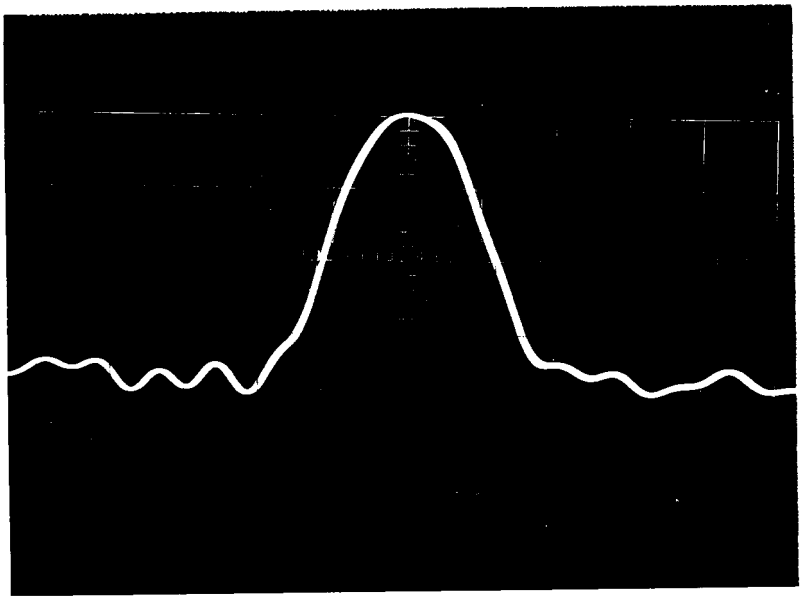


BREADBOARD TRANSMITTER, CFA MODULATOR - Modulator, HVPS, and controls with calorimeter for r-f power measurements and liquid to air heat exchanger. Shown with magnetron mounted for pulser testing.

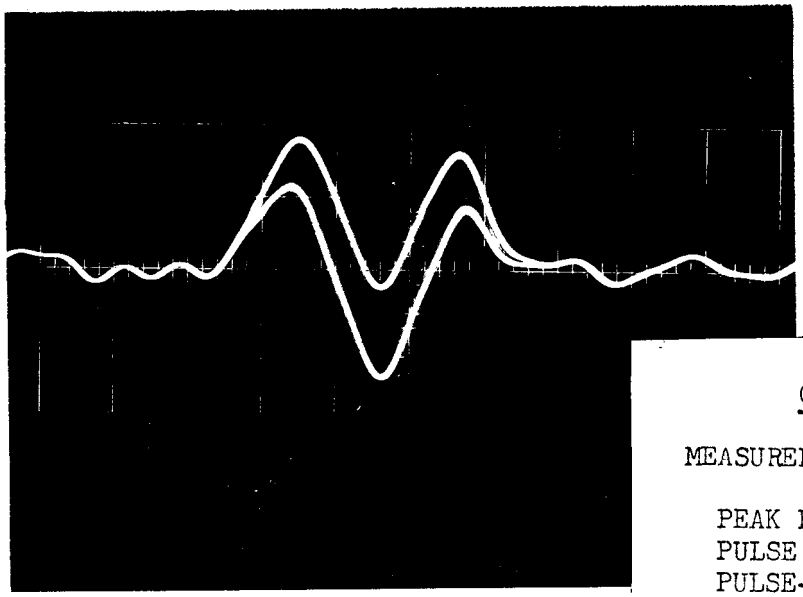


BREADBOARD TRANSMITTER, CFA MODULATOR - Rear view of cabinet showing components and accessories.

CROSS-FIELD AMPLIFIER WAVEFORMS



AMPLITUDE DETECTED R-F PULSE



PHASE DETECTED R-F PULSE
(REFERENCE PHASE-SHIFTED BY 20° TO SHOW PHASE JITTER SENSITIVITY OF 15°/CM)

CROSS-FIELD AMPLIFIER STATUS

MEASURED RESULTS:

PEAK POWER:	600 KW
PULSE WIDTH (-3 db)	40 NANOSEC
PULSE-TO-PULSE PHASE DEVIATION:	1.5° PK-PK
INTRAPULSE PHASE VARIATION:	±30°
GAIN (OVERDRIVEN CONDITION):	16 db

(BOTH PICTURES ARE 1 SECOND EXPOSURE, COMPARABLE TO RADAR DWELL TIME)

ELEMENTS OF MOTION COMPENSATION

ANGLE CORRECTION

ANTENNA PIVOTED AT AFT END

YAW STABILIZATION ±3°

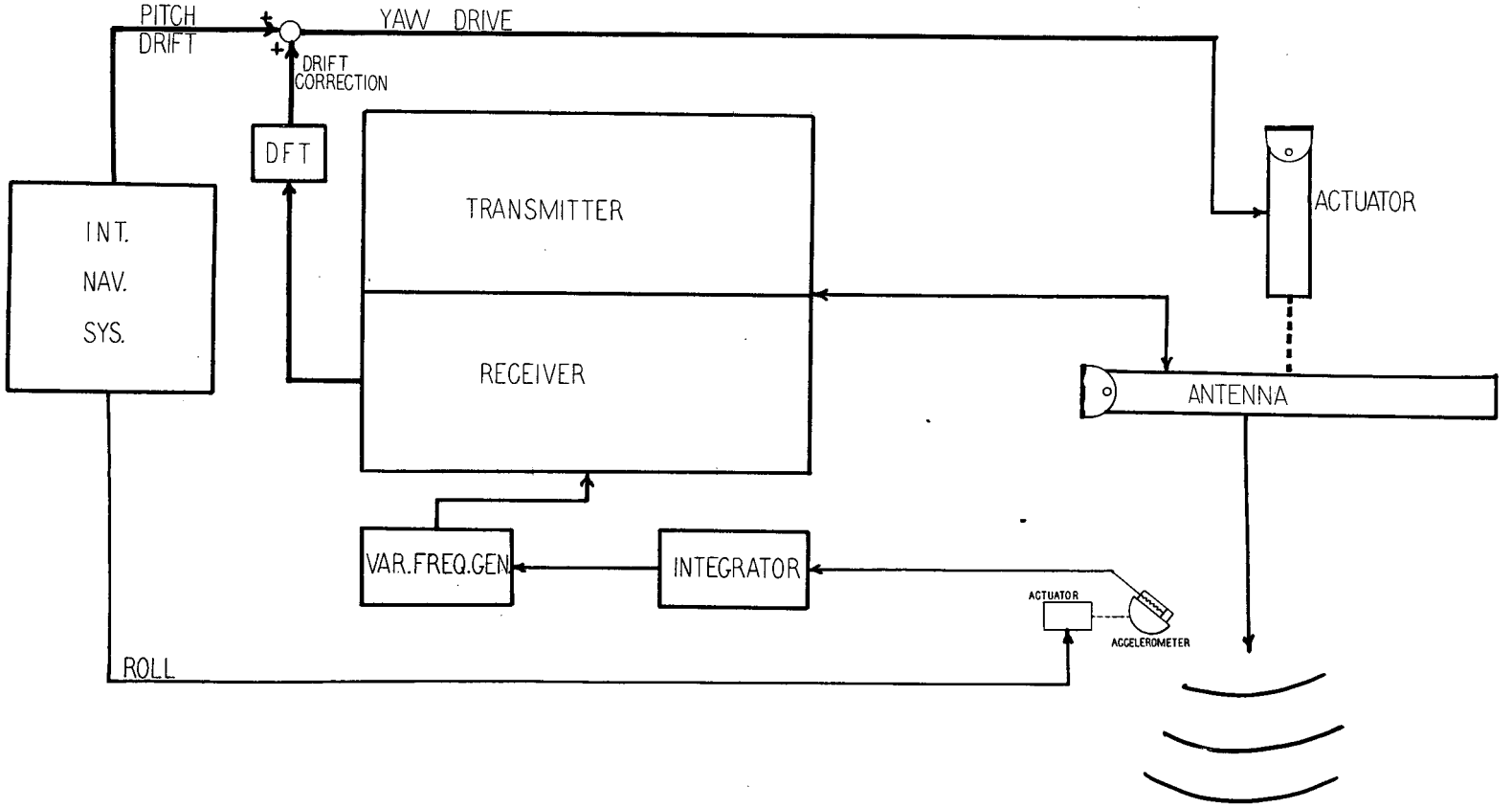
CORRECTS FOR PITCH AND YAW ERRORS

TRANSVERSE VELOCITY CORRECTION

ACCELEROMETER - ROLL STABILIZED

INTEGRATION TO GIVE VELOCITY

CONTROLS VARIABLE FREQUENCY GENERATOR



DESIGN EVALUATION

1. PHASE STABILITY MEASUREMENTS

A. FM DEVIATION OF ALL REFERENCE FREQUENCIES

B. JITTER OF ALL TIMING PULSES : < 4 NANOSEC

C. SYNTHETIC HOLOGRAMS GENERATED - RECORDED - CORRELATED

D. TRANSMITTER SIGNAL RADIATED TO 1 MILE REFLECTOR - RECORDED - CORRELATED

2. RANGE RESOLUTION

A. RECEIVER RESPONSE MEASURED

B. RESOLUTION CHECK OF RECEIVER WITH SYNTHETIC TARGETS - 25 FT. - LIMITED BY FIBER OPTICS

3. AZIMUTH RESOLUTION

A. SYNTHETIC HOLOGRAMS GENERATED - RECORDED - CORRELATED
FOR F-101 CONDITIONS - SHARPENING RATIO OF 100/1 ≈ 10 FT.

4. MISCELLANEOUS

A. INVESTIGATED PULSE OVERSHOOT - CORRECTED BY EXTENDING RECEIVER RESPONSE

B. INVESTIGATED BEST RECORDER - FILM OPERATING POINT - 30% TRANSMISSION

C. DYNAMIC RANGE OF RECEIVER - RECORDER - FILM COMBINATION > 20 db

D. AFFECT OF LIMITING TO INCREASE DYNAMIC RANGE:
IF - NO CLUTTER
VIDEO - BAD HARMONICS

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ENVIRONMENTAL TEST

1. RADIO INTERFERENCE (SYSTEM) .... NO SUSCEPTABILITY
.... MINOR RADIATION

2. EXPLOSION (SYSTEM) ✓

3. VIBRATION

RECEIVER	✓	
SYNCHRONIZER	✓	
NAV. TIE-IN	✓	
POWER SUPPLY	✓	
MODULATOR	✓	
DUPLEX. DRIVER	✓	
RESONANT RING	—	MTG BRACKET FAILED, CORRECTED. RECHECK
TWT		NOISE FIGURE DETERIORATED. RECHECK
RECORDER		MOVEMENT OF LENS. MIRROR

SPECIAL INVESTIGATION
10, 20 ~ FROM POD
120, 160 ~ FROM ENGINE

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4. CRASH SAFETY (SYSTEM) PLANNED

5. TEMP. ALTITUDE (SYSTEM) PLANNED

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FLIGHT TEST

1. FLIGHT S-11 LOC: ANNAPOLIS - SOUTH RIVER
   ALT: 20,000 FT.
   PWR: 0.06 MEG WATTS
   PULSE: 10.0 NANOSEC

   ESTIM. EFFECTIVE RESOL: [redacted] FT

2. MODIFICATIONS TO F-101 INSTALLATION
   A. LENS OPTICS RECORDER IN PLACE OF FIBER OPTICS
   B. TRANSMITTER RESONANT RING LENGTHENED - 10 TO 20 NANOSEC
   C. AUTOMATIC STABILIZATION OF ANTENNA BY DFT

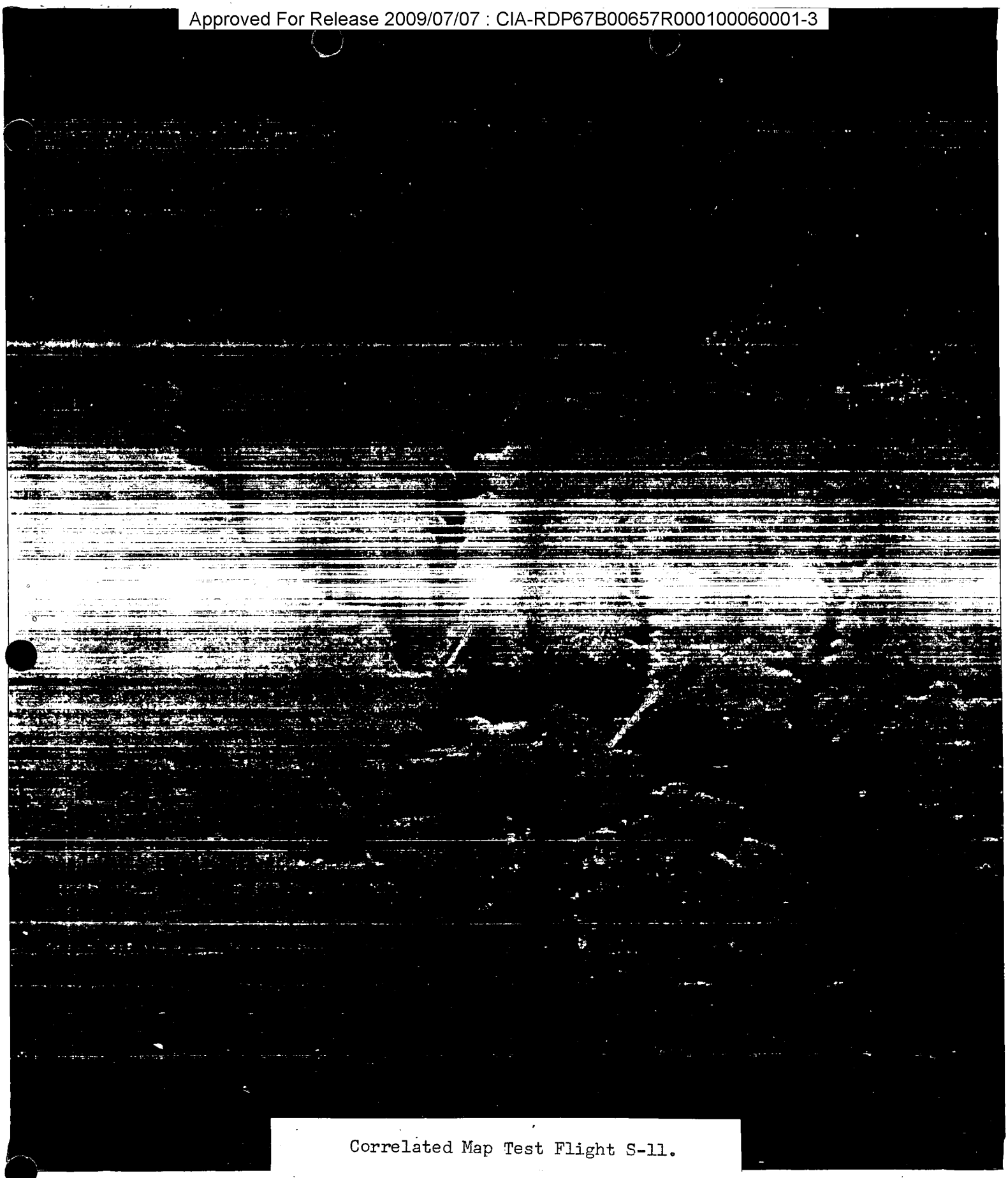
3. FLIGHT S-33 LOC: ANNAPOLIS - SOUTH RIVER
   ALT: 20,000 FT.
   PWR: 0.11 MEG WATTS
   PULSE: 20 NANOSEC

   TARGETS: LEE AIRPORT..... GRASS STRIP, AMONG GRASS
   SO. RIVER BRIDGE..... RE-INFORCED CONCRETE - 30 FT. WIDE
   RIVA BRIDGE..... RE-INFORCED CONCRETE - 30 FT. WIDE
   STEPNEY'S LANE..... MACADAM 30FT, CLEARING 45 FT.
   BOAT PIERS..... WOOD - 5 AND 6 FT. WIDE

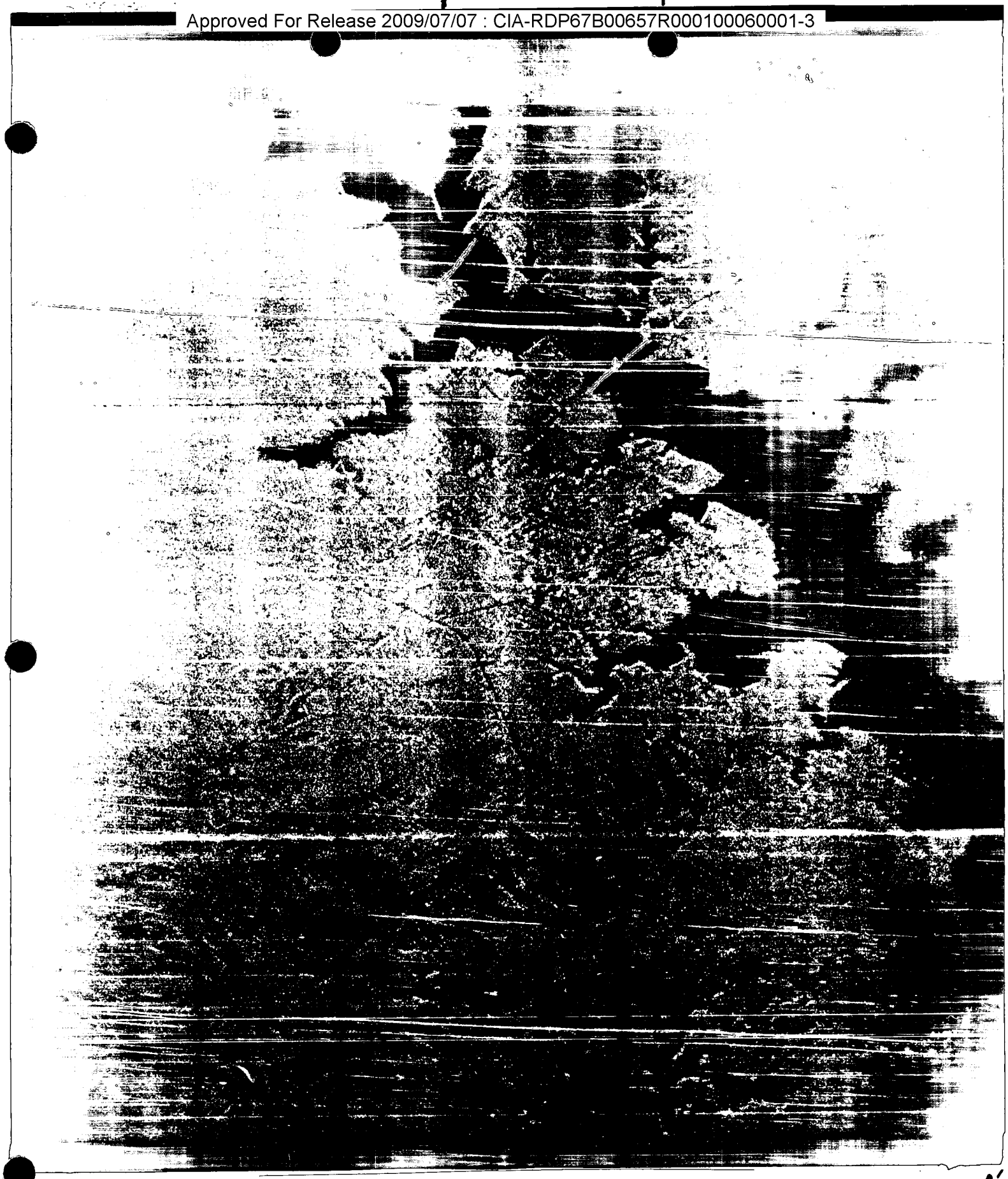
   ESTIM. EFFECTIVE RESOL: [redacted] FT

4. MODIFICATIONS TO F-101 INSTALLATION
   A. MOTION COMPENSATION SYSTEM
   B. GROUND SPEED SIGNAL FOR RECORDER
   C. IF LIMITING

5. MEASURED RANGE FLIGHTS
   A. CAMP CAMPBELL
   B. WILCOX LAKE



Correlated Map Test Flight S-11.



Correlated Map Test Flight S-33.

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Aerial Photo
South River

TARGET DESCRIPTION

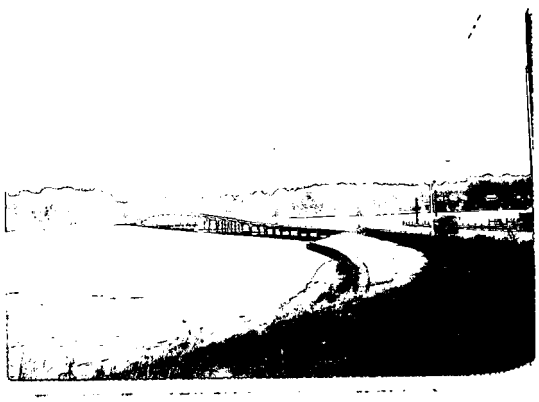
1- LEE AIRPORT STRIP

GRASS RUNWAY
GRASS SURROUNDING

2- SOUTH RIVER BRIDGE

RE-INFORCED CONCRETE,
30 FT. WIDE

3- RIVA BRIDGE



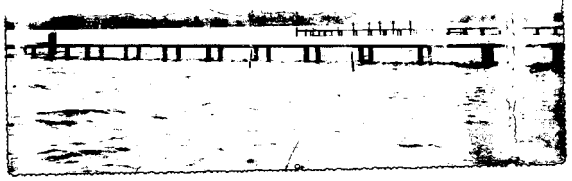
RE-INFORCED CONCRETE,

4- STEINEYS LANE

MACADAM ROAD
30 FT. WIDE

CLEARING
APPROX. 45 FT. WIDE

5- BOAT PIERS



Correlated Data

South River Area	S-33 Print or Film		S-11 Print	
1. airport runway	50 mils	(160')	not visible	
2. lower bridge	10 mils	(32')	50 mils	(160')
3. upper bridge	15 mils	(50')	50 mils	(160')
4. macadam road	10 mils	(32')	off of picture	
5. piers	7-10 mils	(22'-32')	not visible	
minimum size point target	7 mils	(22')	15 mils	(50')
Annapolis Area				
academy object	15 mils	(50')	25 mils	(80')
Annapolis Bridge	7 mils	(22')	not visible	
Annapolis Bridge	10 mils	(32')	25 mils	(80')
boat dock objects	15 mils	(50')	25 mils	(80')
object on bay hook	10 mils	(32')	25 mils	(80')
minimum size point target	7 mils	(22')	15 mils	(50')

Scale Calculations

Scale 9" = 127 usec slant = 60,000' slant

Assume 1 mile dead slant range, so total slant range = 60,000 -6,000

9" = 57,000-1/2 (because only correlate 1/2 of data film)

1 mil = 6.5-1/2 = 3.2'

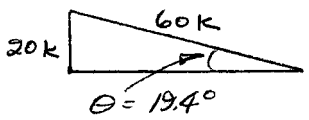
7 mils = 45-1/2 = 22'

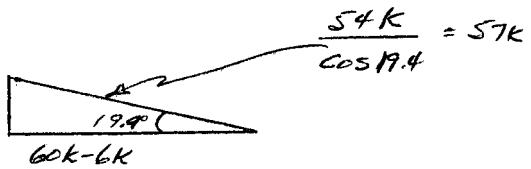
10 mils = 65-1/2 = 32'

15 mils = 100-1/2 = 50'

25 mils = 160-1/2 = 80'

50 mils = 320-1/2 = 160'





ACCESSORY MATERIAL AND SERVICE

1. FIELD SPARES
   REVIEWING - CHANGING IN LINE WITH RADAR

2. FIELD TEST EQUIPMENT
   MODIFYING IN LINE WITH RADAR CHANGES

3. FIELD SERVICE
   ENGINEERS WORKING WITH DESIGN GROUP

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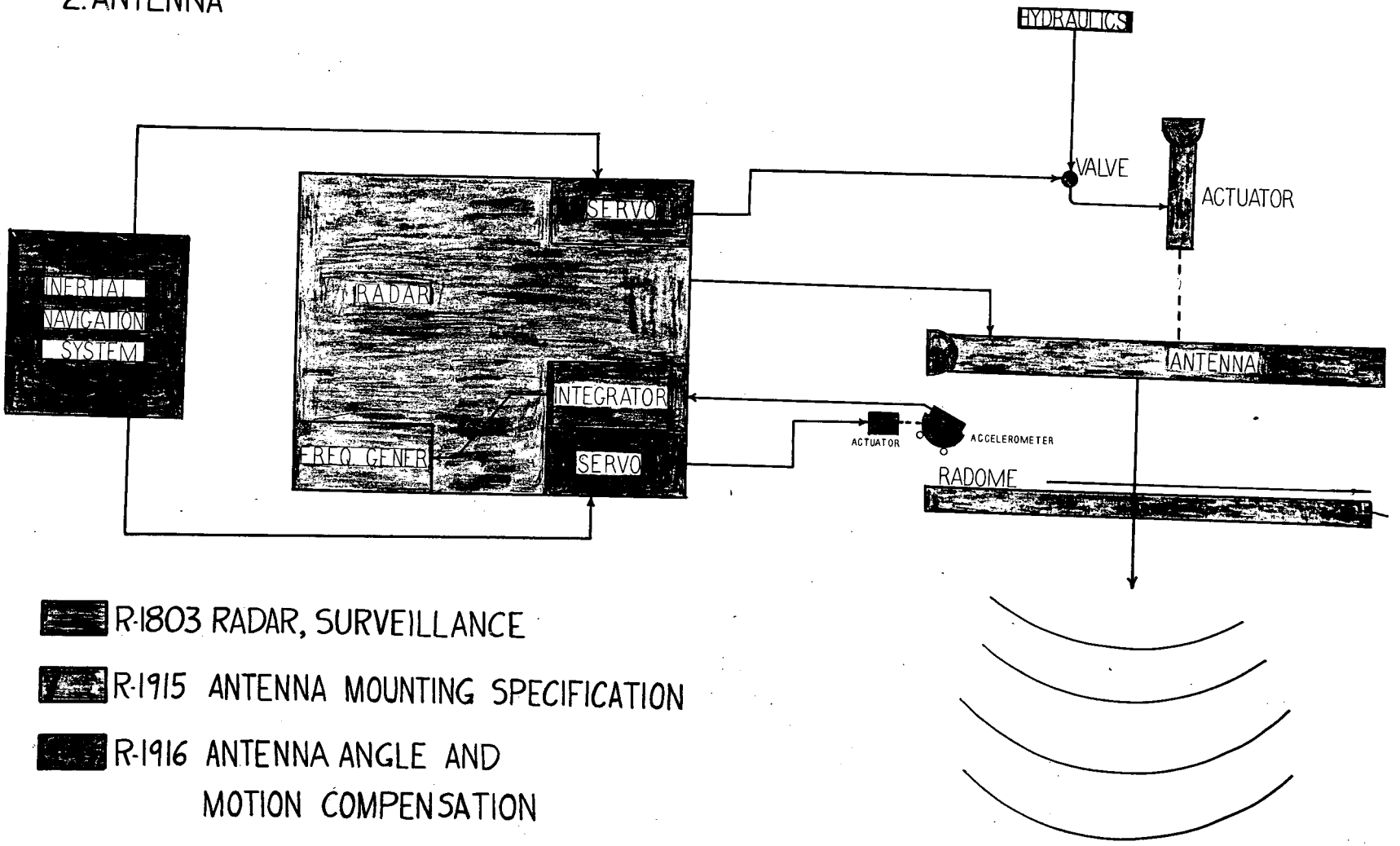
INSTALLATION

1. RADAR ASSEMBLY
2. ANTENNA



- R-1803 RADAR, SURVEILLANCE
- R-1915 ANTENNA MOUNTING SPECIFICATION
- R-1916 ANTENNA ANGLE AND MOTION COMPENSATION

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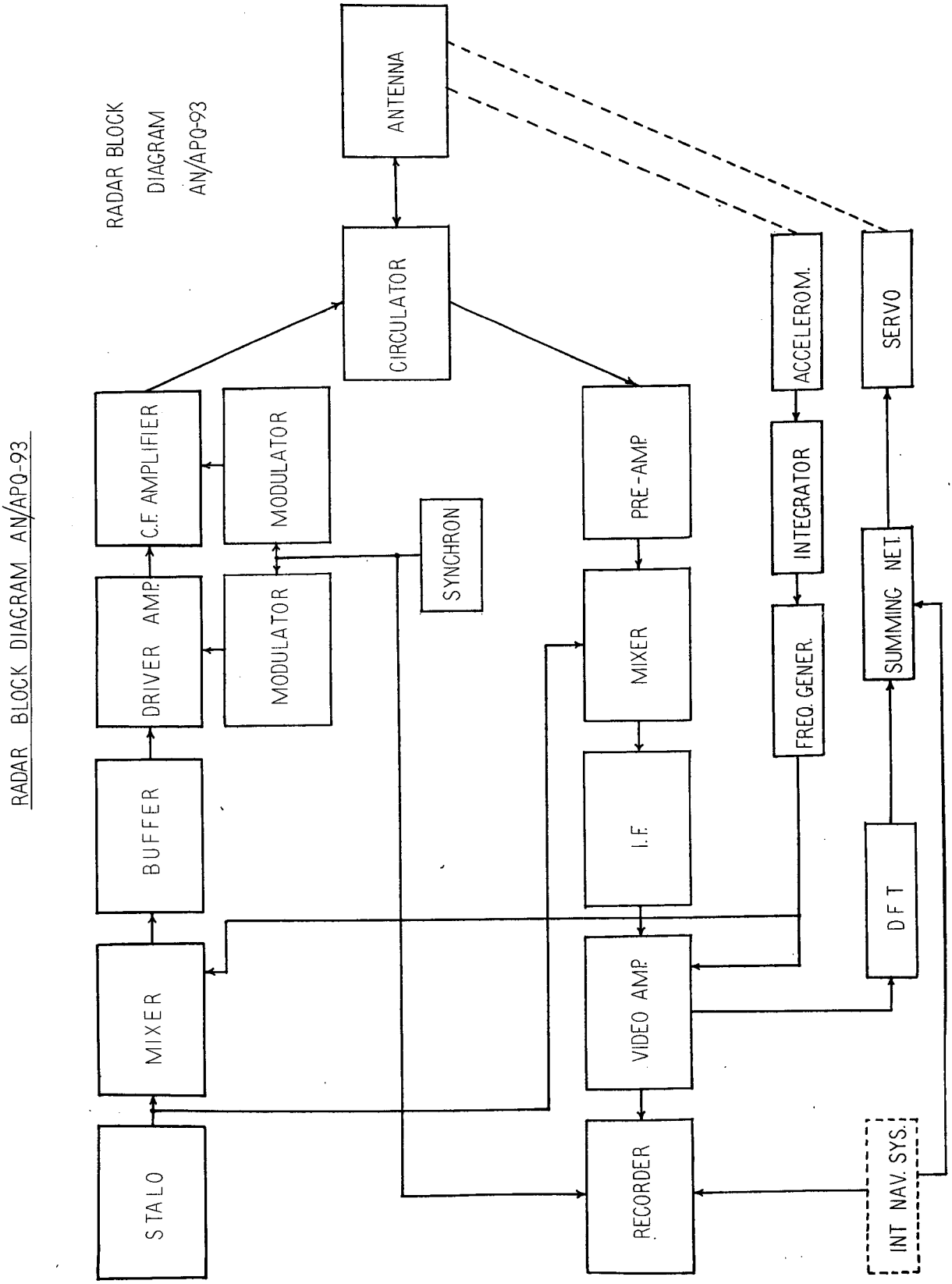
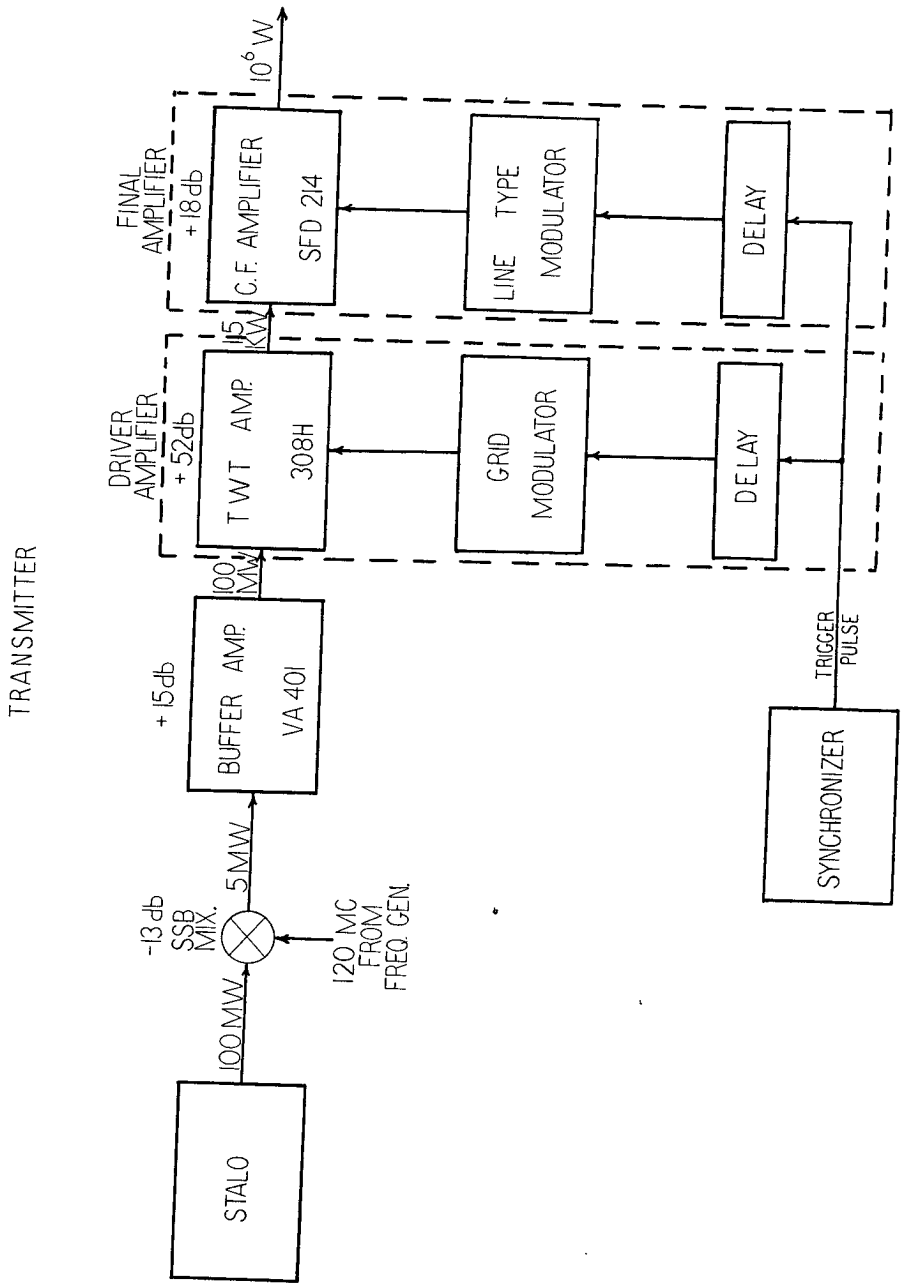
RADAR BLOCK DIAGRAM AN/APQ-93



TRANSMITTER



RADAR PARAMETERS

11/28

TRANSMITTER

FREQUENCY	9400 Mc
PEAK POWER	10^6 WATTS
PULSE WIDTH	30×10^{-9} SEC.
P R F	3927
AVERAGE POWER	118 WATTS

RECEIVER

NOISE FIGURE (TWT PREAMP)	7.5 db
DUPLEXER & LINE LOSSES	2.1 db
CIRCULATOR – 0.25 db (ONE WAY)	
TWT PROTECTOR – 0.4 db	
WAVEGUIDE – 0.65 db (ONE WAY)	
STALO FREQUENCY	9280 Mc
I-F	120 Mc
I-F AMP. BANDWIDTH	60 Mc
VIDEO AMP BANDWIDTH	47 Mc
IMAGE FILTER BANDWIDTH	70 Mc
IMAGE REJECTION	
COHO REF. OFFSET FREQ.	400 cps

ANTENNA

FREQUENCY	9400 Mc
GAIN	31.5 db
AZ BEAMWIDTH	0.75 DEG.
EL BEAMWIDTH	20 DEG.
EL PATTERN	$\csc^2 \cos^{1/2}$
AZ SIDELOBE	–14 db
EL SIDELOBE	–15 db
EL IMAGE PATTERN	–15 db
VSWR	1.3
RADOME LOSS (ONE WAY)	1.75 db

RECORDER

FILM SPEED	2.0"/SEC NOM.
CONTROL RANGE	±10%
CONTROL ACCURACY	0.1%
FILM CAPACITY	250' X 9.5"
CRT SPOT SIZE	0.0005"
SWEEP SPEED	1.02 Mc/30×10^{-9} SEC
TRACK FREQ.	900 CPS (MAX.)

System Weight

Transmitter	210 *
Receiver	27
TWT Preamp	11
Recorder	175 *
Video Amplifier	3
Synchronizer	25
Nav-Tie-In	20 *
Power Supply	70
Control Panel	2
Antenna	140 *
TOTAL	683

System Frame	45 *
Frame Truss	30
Auxiliary Recorder	6
Pressure System	15
TOTAL	96

Total Weight - 779

* Estimated Weight

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